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# Insight into falls prevention programmes for people with visual impairments and intellectual disabilities: A scoping review

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## Abstract

The aim of this study was to review the current literature on falls prevention in people with visual impairment and to estimate the applicability of methods of fall prevention for people with visual impairment and intellectual disability. A scoping review was performed according to the Arksey and O'Malley framework. Relevant studies were collected from PubMed, Web of Science, and the Cochrane Register of Controlled Trials (CENTRAL). All records covering the time span from January 1980 until November 2017 were collected. Studies were included if the participants had a visual impairment according to objective ophthalmic assessments, the article described interventions to reduce falls or risk factors for falls, and the study was written in English and published in a peer-reviewed journal. The methodological quality of the studies were determined by consensus of the authors on the PEDro scale. Fifteen articles were included in this scoping

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review. Three articles focused on screening and intervention programmes, five articles addressed the effectiveness of environmental adjustments, and seven articles involved training programmes for physical improvement. Environmental adjustments emerged as having the best evidence for falls prevention for people with a visual impairment. Physical training programmes improved balance in those with a visual impairment but could not reduce the number of falls. Environmental adjustments also may be effective for persons with a visual impairment and intellectual disability. In addition, multifactorial screening and intervention programmes are recommended as an important new research direction with important clinical implications.

**Keywords**
Falls prevention, intellectual disabilities, occupational therapy, physical therapy, scoping review, visual impairment

## Introduction

Falls can have an immense impact on health and are a major health care problem because of considerable associated costs. At least 30% of people over age 65 years fall once a year (Close, 2013; Lord et al., 1994; Tinetti, Speechley, & Ginter, 1988). Falls lead to adverse consequences, such as fractures, disability, and even death (Cumming et al., 2007). Furthermore, they are related to high costs for society (Javitt, Zhou, & Willke, 2007). Falls prevention is therefore of great importance.

Several studies have investigated effective approaches for falls prevention in the healthy elderly. Some interventions reduce the number of falls while others also reduce the number of fallers. In a review of falls prevention in older people living in the community, Gillespie et al. (2012) found four effective intervention strategies: (1) multifactorial interventions integrating screening for fall risk factors with individualized intervention programmes to reduce the identified risks, (2) medication management (e.g., gradual reduction of psychotropic medication), (3) environmental adjustments (e.g., home safety assessment and modification interventions such as removing loose mats), and (4) training programmes with strength and balance exercises. Environmental adjustments and training programmes reduce the number of falls as well as the risk of falling. The multifactorial screening and adjacent intervention programmes and gradual reduction in psychotropic medication reduce only the number of falls. The level of adherence to individualized recommendations and interventions seems to determine the effect of a multifactorial screening and intervention programme (Gillespie et al., 2012). In addition, the effectiveness of an intervention in the reduction of risk for falling depends largely on the setting of the intervention programme and the population at risk. A Cochrane review indicated that in care facilities and hospitals, vitamin D supplementation and multifactorial interventions seem to reduce the rate of falls (Cameron et al., 2012). In community-dwelling elderly, exercise seems to be the most promising solution to reduce the number of falls (Close, 2013). The above-mentioned differences in effectiveness may be associated with characteristics of the population (active or frail), the involvement of (professional) carers, adherence to a programme, and other logistical considerations.

One of the well-known risk factors for falling is having a visual impairment (Close, 2005). One review showed that elderly persons with reduced visual acuity are 1.7 times more likely to fall and 1.9 times more likely to have multiple falls compared to their fully sighted peers (Legood, Scuffham, & Cryer, 2002). The definition of a visual impairment established by the World Health Organization (2016) and used in the International Classification of Diseases is a best-corrected visual acuity of less than 0.3 (20/60) but no less than 0.05 (20/200) in the better eye. In the Netherlands, the prevalence of visual impairment ranges from 0.1% in persons aged 55–64 to

11.8% in persons aged 85 years or older (Klaver, Wolfs, Vingerling, Hofman, & de Jong, 1998). The first step in the prevention of falls is to detect the persons at risk for falling. Many factors can contribute to an increased risk for falls, for example, advanced age and mobility problems. Another major factor is having a visual impairment. The Visual Impairment Detection Program by McGraw, Dery, and Wittich (2011) describes how to detect visually impaired persons who are at risk for falling. However, the focus of this review is on fall prevention interventions for persons with non-correctable permanent vision loss.

For persons with a visual impairment, adjustments likely should be made to all types of fall prevention interventions described by Gillespie et al. (2012), except for medication management as having a visual impairment does not influence the working mechanism of medicine. A qualitative study on accessibility of fall prevention programmes for older adults with visual impairments revealed that the most frequently mentioned key elements of an accessible intervention are an accessible location, written information tailored to persons with visual impairments, and multiple delivery methods (Blaylock, Vogtle, & Warren, 2017). For multifactorial screening, the emphasis should be on the vision screening, and some adjustments should be made in the instruments used to measure a specific risk factor. For instance, assessment of postural stability by means of a balance or gait test in which a person needs to walk a specific distance in time will probably be influenced by the limited vision (Aartolahti et al., 2013). A review of the visual risk factors for falls in older people has shown that reduced contrast sensitivity and depth perception are the most important visual risk factors for falls (Lord, 2006). Environmental adjustments therefore need to be tailored to the visual impairment as well. A Cochrane review was done on environmental and behavioural interventions to reduce limitations in physical activity in older persons with a visual impairment living in the community. This review was inconclusive about the effectiveness of both types of programmes for elderly persons with visual impairment and did not investigate the effect on falls (Skelton et al., 2013). Another review on physical training in persons with a visual impairment showed that training programmes can improve physical function, but the effect on falls is still unclear (Gleeson, Sherrington, & Keay, 2014).

Another population with an increased risk for falling is persons with intellectual disabilities (ID) (Enkelaar, Smulders, van Schrojenstein Lantman-de Valk, Weerdesteyn, & Geurts, 2013; Smulders, Enkelaar, Weerdesteyn, Geurts, & van Schrojenstein Lantman-de Valk, 2013). Among persons with ID, visual impairments occur more frequently than in the general population (Evenhuis, Theunissen, Denkers, Verschuure, & Kemme, 2001). In persons with ID, 4% of individuals with mild/moderate ID under age 50 years and 7.5% in persons over age 50 are visually impaired (Enkelaar, Smulders, van Schrojenstein Lantman-de Valk, Geurts, & Weerdesteyn, 2012; Jansen, Krol, Groothoff, & Post, 2004). These percentages are much higher in older persons with Down syndrome (31%) and in persons with severe/profound ID (above 51%) (Evenhuis et al., 2001). People with ID also have increased risk for conditions such as epilepsy and sensorimotor impairment (Enkelaar et al., 2012; Jansen et al., 2004), which can result in an even greater risk for falling. The risk for falling in persons with both visual impairments and ID is likely even higher than for those with a visual impairment alone. Although persons with a visual impairment and ID are at increased risk for falls, no research has been done on effective interventions for falls prevention in this population.

Considering the above-mentioned studies, gaps remain in the knowledge about preventing falls in persons with visual impairment or both visual disability and ID. Therefore, the current state of knowledge needs to be aggregated for a better view of these gaps and the possibilities for prevention in these vulnerable groups. Research into falls prevention for the visually impaired is limited, as well (Blaylock & Vogtle, 2017), but can give a better direction for selecting falls prevention interventions for someone with both visual impairment and ID. As no information seems to be

available on fall prevention interventions for persons with a visual impairment and ID, a scoping review was performed according to the Arksey and O'Mally (2005) framework focusing on falls prevention in persons with visual impairment only. The applicability of these falls prevention interventions for persons with both visual impairment and ID is then discussed.

## Methods

The Arksey and O'Malley's (2005) methodological framework for developing a scoping review was used with the refinements by Levac, Colquhoun, and O'Brien (2010). This framework consists of six stages: (1) identifying the research question; (2) identifying relevant studies; (3) study selection; (4) charting the data; (5) collecting, summarizing, and reporting the results; and (6) consultation.

### *Identifying the research question*

The aim of this scoping review was to summarize what is known from the current literature on falls prevention in persons with visual impairment and to discuss which interventions would be also applicable for persons with both visual impairment and ID.

### *Identifying relevant studies*

To identify relevant studies, the following databases were searched: PubMed, Web of Science, and the Cochrane Register of Controlled Trials (CENTRAL). The search aimed to include all studies that investigated possible approaches to falls prevention in persons with a visual impairment. All records covering the time span from January 1980 until November 2017 were collected. The PubMed search strategy included the following Medical Subject Headings (MeSH) terms: Vision Disorders, Visually Impaired Persons, Accidental Falls, Accidents, Accident Proneness, Accident Prevention, and Intervention Studies. Furthermore, the following search words were used: (low* or handicap* or subnormal* or impair* or partial* or disab*) AND (vision or visual* or sight) for visual impairments, (Fall*) for falls and (Intervention*) for interventions. This strategy was adapted for the other databases.

### *Selecting relevant studies*

To select relevant studies, the first and second author independently screened all titles and abstracts for relevance. Subsequently, the full-text articles were checked, and studies were included if they met the following criteria: the participants had a visual impairment, objective ophthalmic assessments were used, the outcome measures were focused on falls or risk factors for falls, the article described an intervention for falls prevention, the study was published in a peer-reviewed journal, and the article was written in English. Studies were excluded if the intervention tried to cure the visual impairment, for instance, by surgical operations. In Figure 1, the flowchart of the literature search gives an overview on this process. Agreement between the first and second author about inclusion was reached through discussion.

### *Charting the data*

The information charted from the studies included the design, patient characteristics, outcome measures, and main results of the studies. These results are reported in Table 1. Furthermore, the scores on the PEDro scale were determined by consensus of the first two authors, to get an

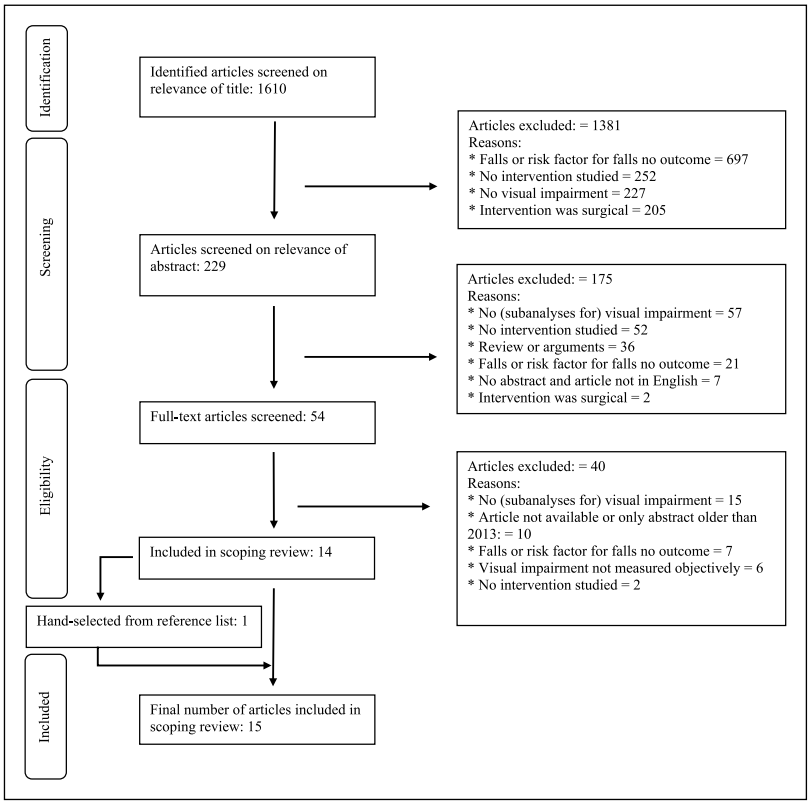


**Figure 1.** Flowchart of the literature search.

impression on the methodological quality of the studies (De Morton, 2009; Maher, Sherrington, Herbert, Moseley, & Elkins, 2003; Verhagen et al., 1998).

## Results

### *Collecting, summarizing, and reporting the results*

In total, the search yielded 1610 references. The titles were checked, and 229 articles were included. The abstracts then were checked based on the inclusion criteria, resulting in the exclusion of 175 articles. Reasons for exclusion were that falls or fall-related risk factors were not the outcome measure, no intervention was studied, or the people falling did not have a visual impairment (see Figure 1 for further exclusion reasons). Some of the excluded articles were found based on another meaning of the words blind (e.g., double-blind study) and fall. Furthermore, a number of titles concerned driving skills in the elderly or persons with a visual impairment and focused on safety instead of falling. Moreover, many articles described the association of visual functioning and the risk of falling and did not examine falls prevention. Ultimately, 1596 studies were excluded for not meeting the inclusion criteria. In total, 54 full-text articles were screened, which led to the inclusion of 14 articles that met the inclusion criteria. The reference lists of the remaining 14 articles were checked for supplementary relevant studies, and one more relevant article met the inclusion criteria. In total, 15 articles were selected for this review. For the total search outline, see Figure 1.

**Table 1.** Characteristics of included studies on falls prevention in persons with a visual impairment ($N = 15$).

| Study | Design | Population | *n* | Age and sex | Visual acuity | Intervention | Intensity/follow-up | Outcome measures | Results | PEDro-score |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Screening and intervention programmes on specific risk factors for falls | | | | | | | | | | |
| Alma, Groothoff, Melis-Dankers, Suurmeijer, and Van der Mei (2013) | Single group pretest–posttest pilot study | Residential facility | 29 | Mean age 73 ± 8 yr. 11 M/18 F | Mean 0.88 LogMAR (binocular) | A multi-disciplinary group rehabilitation programme, Visually Impaired elderly Persons Participating (VIPP) | 20 weeks, 2-hr group session per week | Psychosocial adaptation to vision loss. Helplessness. Self-efficacy, mental health, and fear of falling | Helplessness and generic and vision-specific fear of falling decreased after VIPP ($\eta^2$ 0.26, 0.20 and 0.240, not significant | 2/10 |
| Haran et al. (2010) | RCT | Community dwelling | 606, 305 IG, 301 CG | Mean age 80 ± 7 yr. 213 M/393 F | Not specified | Single lens distance glasses | 12 months (follow-up) | Number of falls and injuries | 8% reduction of falls in intervention group compared to usual care (incidence rate ration, 95% CI, 0.92 [0.73, 1.16]), not significant | 8/10 |
| Cumming et al. (2007) | RCT | Community dwelling | 616, 309 IG, 307 CG | Mean age 81 ± 6 yr. 198 M/418 F | Mean VA 0.22 LogMAR (Interv) | Comprehensive vision and eye examinations | 12 months (follow-up) | Falls and fractures | More falls in intervention group than in control group (falls rate ration, 95% CI, 1.57, [1.20, 2.95]; $p = .001$) | 6/10 |
| 2. Interventions directed at environmental adjustments | | | | | | | | | | |
| Waterman et al. (2016) | RCT | Community dwelling | 49, 16 HS, 17 HE, 17 C | Mean age 81.4 ± 7.6 yr. (65–96) 17 M/32 F | VA > 0.6 LogMAR and/or moderate visual field loss of >20% | Home safety (HS) and Shortened version of Otago Home Exercise (HE) programme | 6 months (follow-up) | Falls | Adherence to HS was good, to HE less clear. HE self-reported physical activity increased, but decrease in walking activity. No significant differences in falls | 7/10 |
| Pundlik, Tomasi, and Luo (2015) | Experimental design | Community dwelling | 25 | Median age 56 yr. (36–85) 16 M/9 F | Visual field loss 12 hemianopia, 12 tunnel vision, 1 optic nerve damage Median VA 0.204 LogMAR | Use of a collision warning device in an obstacle course | Four loops on a 41-m-long obstacle course with and without warning device | Number of collisions and walking speed | Significantly less (5%) collisions with device ($p < .001$) | 2/10 |
| Foster, Hotchkiss, Buckley, and Elliott (2014) | Experimental design | Community dwelling | 16 old, 8 young SVI | Mean age 71 ± 1 yr., 8 M/8 F Mean age 24 ± 4 yr. 5 M/3 F | Normal vision, Simulated Contrast sensitivity reduced to ±0.75 log units | Edge highlighter and its location (direct, at 10 or 30 mm) on stairs | 3 times on a 3 step stair with different positions of tread edge highlighter | Foot placement/ clearance and number of accidental foot contacts | In elderly edge highlighter changed foot clearance parameters ($p < .001$). In SVI edge highlighter direct to tread edge reduced accidental foot contacts (15→3%). | 2/10 |
| La Grow, Robertson, Campbell, Clarke, and Kerse (2006) | RCT | Community dwelling | 391, 100 HS, 98 HS + HE, 97 HE, 96 SV | Age ⩾ 75 yr. 124 M/267 F | VA ⩽ 6/24 | Home safety (HS) assessment, Otago exercise (HE), social visits (SV) | HS (2 visits), HE (5 visits, E, 3x + 2x walking week), SV (2 visits)→12 months (follow-up) | Type and number of hazardous falls | Both falls related and unrelated to environmental hazards were reduced in the home safety programme compared to social visits (incidence rate ration, 95% CI, 0.40 [0.21, 0.74]) | 8/10 |

**Table 1.** (Continued)

| Study | Design | Population | *n* | Age and sex | Visual acuity | Intervention | Intensity/follow-up | Outcome measures | Results | PEDro-score |
|---|---|---|---|---|---|---|---|---|---|---|
| Campbell et al. (2005) | RCT | Community dwelling | 391, 100 HS, 98 HS + HE, 97 HE, 96 SV | Age ⩾ 75 yr. 124 M/267 F | VA ⩽ 6/24 | Home safety (HS) assessment, Otago exercise (HE), social visits (SV) | 16 weeks | Falls | Less falls in home safety programme, no significant difference in exercise programme (incidence rate ratio, 95% CI, 0.59 [0.42, 0.83] and (1.15 [0.82, 1.61]), poor adherence to HE | 8/10 |
| 3. Training programmes | | | | | | | | | | |
| Jeter, Moonaz, Bittner, and Dagnelie (2015) | A pilot RCT | Community dwelling | 21, 11 IG, 10 CG | Mean age 55 yr. M = 6/F = 15 | ⩽ 20/200 | Ashtanga-based Yoga Therapy (AYT) | 8 weeks, 2 individual home-based sessions per week | Sway of Centre of Pressure EO, EC, EO Foam and EC Foam | Mean total velocity of COP, OLS, chair sit & reach, 30-s chair stand increased in AYT ($p \leqslant .04$), no difference from pre-test to post-test in control group ($p > .05$) | 6/10 |
| Gleeson, Sherrington, Lo, and Keay (2015) | RCT | Community dwelling | 120, 60 IG, 60 CG | Mean age 75 ± 11 yr. M = 35/F = 85 | | Alexander technique (AT) | 12 weeks, once a week a 30-min lesson | Falls<br>Postural sway, max balance range | No sign diff, but promising results in favour of AT | 8/10 |
| Hackney, Hall, Echt, and Wolf (2015) | CT | Community dwelling | 32, 14 IG, 18 CG | Mean age 79 ± 10 yr. M = 15/F = 17 | ⩽ 20/60 in best eye | Adapted Tango or FallProof programme | 12 weeks, 20 lessons of each 90 min | BBS, SOT postural sway, Dynamic Gait Index, TUG, 6MWT, Gait speed, vision related QOL | Both interventions improved on BBS and SOT ($p < .001$). Tango more improvement in 6MWT, TUG (cogn. dual-tasking) and QOL | 4/10 |
| Shin, Choi, Lim, Cho, and Lim (2015) | CT | Residential facility | 20 | Mean age 26 yr. M = 16/F = 4 | Low vision or blind | Indoor rowing exercise | 6 weeks (5 days a week, 40 min rowing) | Laboratory data, body composition, physical fitness, Cobb's angle, and fall index | Back strength increased significantly ($p = .008$) and body fat decreased significantly ($p = .006$) | 4/10 |
| Kovács et al. (2012) | RCT | Residential facility | 41, 21 IG, 20 CG | Mean age 69 ± 7 yr. F only | | Otago exercise programme | IG (2x week a 30 min OE lesson + 2x week 30 min osteoporosis group lesson), CG (4x week 30-min osteoporosis group lesson), 6 months (follow-up) | Falls<br>BBS<br>TUG<br>Barthel Index | Less falls in Otago exercise but not sign. and better TUG ($p = .001$) | 8/10 |
| Chen, Fu, Chan, and Tsang (2012) | RCT | Residential facility | 40, 21 IG, 19 CG | Mean age 84 ± 7 yr. M/F | ⩾ 3/60, ⩽ 6/18 or ⩽ 3/60 | Tai Chi or music percussion session | 3x week, 1.5 hr group for 16 weeks | Muscle strength, proprioception, sensory test | Better proprioception ($p = .032$) and sensory test ($p = .024$) in Tai Chi group | 4/10 |
| Jazi, Purrajabi, Movahedi, and Jalali (2012) | RCT | Children with visual impairments | 19, 9 IG, 10 CG | Mean age 10 ± 2 yr. 12 M/7 F | ⩽ 20/70 in best eye after correction | Balance training programme vs. no training | 2x week, 1 hr group for 8 weeks | Modified Bass Test of Dynamic Balance | Better balance in balance group ($p < .05$) | 2/10 |

6MWT: 6-Minute Walking Test; AT: Alexander Technique; AYT: Ashtanga-based Yoga Therapy; BBS: Berg Balance Scale (assesses balance); COP: centre of pressure (assesses balance); CI: confidence interval; CG: control group; CT: controlled trial; EC: eyes closed; EO: eyes open; F: female; IG: intervention group; LogMAR: logarithm of the minimum angle of resolution; M: male; OLS: one leg stance; QOL: quality of life; RCT: randomized controlled trial; SOT: sensory organization test (assesses postural sway) SVI: simulated visual impairment; TUG: timed up and go; VA: visual acuity; yr.: year.

In Table 1, the charted data of the 15 studies on falls prevention in persons with a visual impairment are presented. Similar to the review by Gillespie et al. (2012), we report the results and distinguished the articles according to screening and intervention programmes on risk factors for falls, environmental adjustments, and training programmes.

### *Articles about (multifactorial) screening and intervention programmes on risk factors for falls in persons with a visual impairment (n = 3)*

The studies about screening and intervention programmes comprised one pilot study about a multidisciplinary group rehabilitation programme on fear of falling and two randomized controlled trials (RCTs) about vision screening and interventions related to vision to reduce the number of falls. The methodological quality of the RCTs was moderate (PEDro score of 6 out of 10; $n = 1$) to good (PEDro score of 8 out of 10; $n = 1$). The study of Cumming et al. (2007), with good methodological quality, showed that in frail older people, comprehensive vision and eye assessment does not reduce, and may even increase, the risk for falls and fractures after appropriate treatment (e.g., providing glasses). On the contrary, the study of Haran et al. (2010), with moderate methodological quality, showed that with appropriate counselling, provision of single lens glasses is an effective fall prevention strategy for older wearers of multifocal glasses who take part in regular outdoor activities. Even though the study of Alma et al. (2013) was a pilot study, it showed promising results in reducing the vision-specific fear of falling after a multidisciplinary group rehabilitation programme.

### *Articles about environmental adjustments in persons with a visual impairment (n = 5)*

Five studies were included on interventions directed at environmental adjustments for falls prevention in persons with a visual impairment. Three RCTs with good methodological quality (PEDro scores of 7 or 8 out of 10) were found on the effectiveness of home safety programmes. In these home safety programmes, occupational therapists screened a person's home with a home safety assessment checklist to identify hazards and gave recommendations and guided the modification of these home hazards for falls prevention. Some examples of home modifications made in the studies were removing loose mats or installing hand or grab rails along stairs or in the bathroom, shower, or toilet. In two of the three studies, this type of home modification significantly reduced the number of falls (Campbell et al., 2005; La Grow et al., 2006). In one study with a much smaller sample size, however, it did not (Waterman et al., 2016).

In addition to the home safety programmes, two experimental studies were identified. The first was an experimental study indicating that for older persons with visual impairment, safety on stairs was improved by a high-contrast edge highlighter positioned along the edge of each tread (Foster et al., 2014). Second, Pundlik et al. (2015) found that a collision warning device significantly reduced the number of collisions in an obstacle course. Whether these last two studies will reduce the number of falls in daily life remains to be determined. Together, the above-mentioned studies show that several environmental adjustments can contribute to decreased fall risk and frequency in persons with a visual impairment.

### *Articles on training programmes in persons with a visual impairment (n = 7)*

Most articles found on falls prevention in persons with a visual impairment covered training programmes. The studied training programmes were yoga (Jeter et al., 2015), the Alexander technique (Gleeson et al., 2015), Tango (Hackney et al., 2015), indoor rowing (Shin et al., 2015), the Otago

Exercise programme (Kovács et al., 2012), Tai Chi (Chen et al., 2012), and balance training programmes (Jazi et al., 2012). The methodological quality of these studies ranged from very poor (PEDro scores of 2 to 4 out of 10; $n=4$) to moderate (PEDro score of 6 out of 10; $n=1$) to good (PEDro scores of 8 out of 10; $n=2$). All training programmes gave positive results on the outcome measures of balance or strength, but no significant changes could be identified in the number of falls. The only study that found a trend towards falls reduction was conducted by Kovács et al. (2012). The Otago Exercise programme in that study resulted in fewer falls in the intervention compared to the control group, but the difference between the groups was not significant.

## Discussion

This scoping review brings together articles since 1980 on falls prevention in persons with a visual impairment. This review suggests that environmental adjustments are the best method to reduce the number of falls in this population (Campbell et al., 2005; La Grow et al., 2006). The studies on screening and intervention programmes targeted only the visual impairment and had contradictory results on falls (Cumming et al., 2007; Haran et al., 2010). Studies that used training programmes did improve balance and strength in persons with a visual impairment but could not significantly reduce the number of falls (Chen et al., 2012; Gleeson et al., 2015; Hackney et al., 2015; Jazi et al., 2012; Jeter et al., 2015; Kovács et al., 2012; Shin et al., 2015).

Although a multifactorial screening and intervention programme is a promising intervention for falls prevention in persons without a visual impairment (Gillespie et al., 2012), no studies were found that evaluated a multifactorial intervention with an integrated screening on all possible risk factors for falls combined with an individualized intervention programme specific for people with these impairments. Only studies screening for one specific risk factor, namely diminished vision, were found (Cumming et al., 2007; Haran et al., 2010). Because the risk of falling depends on multiple components, diminishing this risk to one single focus in intervention is difficult. This problem might explain the contradictory results from the studies targeting only the visual impairment. In Cumming et al. (2007), vision assessment and associated interventions even increased the number of falls and number of people falling compared to the control group. On the other hand, Haran et al. (2010) found that providing single lens glasses in those spending more time outdoors reduced falls but increased outdoor falls in frailer people who took part in few outside activities compared to the care-as-usual group. Taken together, these studies show that falls prevention measures should consider the person's exposure to risk factors. For instance, if people improve their vision by new spectacles and become more active but their balance does not improve, the risk for falls will probably increase.

Reported training programmes had a positive effect on balance and motor skills in people with a visual impairment but could not effectively diminish falls. Because measuring an event, which does not occur, provides a methodological challenge – falls do not happen every day – it is possible that the sample sizes of most of the studies were too small to have had enough power to establish an effect on falls, even if the methodological quality of the study was high. In addition, the effect of an intervention to reduce the number of falls may take some time. For this reason, the Prevention of Falls Network Europe recommends that fall prevention intervention studies require longer-term follow-up of at least 12 months (Lamb, Jørstad-Stein, Hauer, & Becker, 2005). In all included studies, the follow-up time was shorter than 1 year, so the effect on falls might not have become manifest yet. The study with the longest follow-up (6 months) did show a trend towards fewer falls, although the effect was not significant (Kovács et al., 2012). Further research should show whether a longer follow-up period results in fewer falls for persons with a visual impairment, with or without ID, and whether an improvement of motor skills is the effective mechanism in this reduction in falls.

None of the studies we found on falls prevention in persons with visual impairment reduced the number who fell, and only a reduction in the number of falls was found. A possible explanation for this outcome might be twofold: (1) persons with visual impairment are at such a high risk for falls that reducing the number of people falling may be a too-ambitious goal and (2) multiple factors contribute to the risk of falls in this specific population, so that falls prevention also needs to target multiple aspects, something that remains uncommon in current studies. This gap emphasizes the need to investigate the effectiveness of a specifically tailored multifactorial screening and intervention programme for reducing the number of people with visual impairments, with or without ID, from falling. One important aspect to consider in future research is to specifically take into account the personal circumstances of the person receiving the intervention, which has been shown to largely influence the reduction of falls (Cameron et al., 2012).

### *Falls prevention for persons with a visual impairment and ID*

A second aim of this review was to examine which fall prevention programmes for persons with visual impairment might also be applicable for persons with both visual impairment and ID. No articles are available about effective interventions for falls prevention for this specific vulnerable group. In one study regarding falls prevention in persons with ID only, a multifactorial screening and intervention programme was applicable for this population (Smulders et al., 2013). With adjustments, this intervention may also be appropriate for persons with visual impairment and ID. Previous research has shown that high-risk groups benefit most from multifactorial screening and intervention programmes (Close, 2013). Based on the findings of this current review that focused on persons with visual impairment, environmental adjustments may also be effective in diminishing the frequency of falls in people with both visual impairment and ID.

Despite the lack of research on effective interventions for falls prevention for persons with visual impairment and ID, previous studies on learning behaviour of people with ID provide indications of the prerequisites for an effective intervention. Because people with ID may not understand or have a good overview of the complex interplay of personal and environmental factors that contribute to falls risk, proper guidance by carers is important for this population (Enkelaar et al., 2013). In addition, for persons with a visual impairment and ID, it is at least as important as for persons with a visual impairment that the risk exposure level is proportional to the person's ability. Furthermore, people with ID learn more often by doing and practice than through theoretical education (Atwell, Conners, & Merrill, 2003). An intervention on falls prevention for this population should therefore be practice-based. A home-based exercise programme with independent homework exercises is probably less suitable for this population. Although speculative, a group-based exercise programmes like obstacle course training for persons with ID, as described by Van Hanegem, Enkelaar, Smulders, and Weerdesteyn (2014), might be applicable. All of these interventions will need adjustments to be suitable for persons with a visual impairment and ID.

### *Recommendations for further exploration*

One study on falls prevention investigated the use of technology. The use of an auditory collision warning device significantly reduced the number of collisions in an obstacle course with high-level obstacles (Shin et al., 2015). Because most falls (59%) occur as a result of trips and slips (Berg, Alessio, Mills, & Tong, 1997), the effect of the use of sensors on floor-level obstacle collisions is even more relevant in relation to falls prevention in persons with visual impairments. The possibility of using sensors also was mentioned in a study of needs in the care of persons with a visual impairment or visual impairment and ID (Woensdregt, D'Addabbo, Scholten, van Alfen, & Sterkenburg, under revision). For persons with a visual impairment and ID, technology

can be highly effective. Especially because technology is always developing and sensors are becoming easier to use and more affordable these days, it will be interesting to add the use of sensors as warning devices to new training programmes to prevent falls in persons with a visual impairment and ID.

### *Recommendations for clinical practice*

Our first suggestion for clinical practice regarding falls prevention for persons with a visual impairment, with or without ID, would be to use an individualized screening procedure with multiple components regarding both the individual and the environment, combined with intervention strategies tailored to the specific situation and needs of each individual. Although no hard evidence for the effective reduction of falls in persons with visual impairment and ID has been found, this might be the next best option. Research with the elderly has indicated that multifactorial screening and intervention programmes are effective only with proper adherence (Gillespie et al., 2009), appropriate counselling, and clear instructions. Therefore, it is crucial that multifactorial screening and intervention programmes for persons with visual impairments should give information with multiple delivery methods about how specific intervention strategies need to be applied in daily life (Blaylock & Vogtle, 2017) and how adherence to these intervention strategies will be effective in preventing falls. Based on the results of this review, we suggest to specifically including environmental adjustments in the intervention strategies of multifactorial screening and intervention programmes.

## Conclusion

Persons with a visual impairment are at high risk for falls. The most promising single method for falls prevention for persons with a visual impairment seems to be to adjust the environment. The next step in falls prevention for this population is to investigate the efficacy of a specially tailored multifactorial screening and intervention programme, in which adaptations of the environment represent one of the intervention strategies. For persons with visual impairments and ID, multifactorial screening and interventions are also recommended to reduce falls in this high-risk group. The effectiveness of a multifactorial screening and intervention programme so far has not been studied in persons with visual impairment with or without ID. This area will be an interesting new research direction with high clinical implications because the prevalence of visual impairments is high among the elderly. In addition, more research is needed to determine whether training programmes can reduce falls in persons with a visual impairment. If so, effective elements of these training programmes also can be used in multifactorial intervention programmes.

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